TEXTILE RESEARCH

Publication of

United States Institute for Textile Research, Inc.

CHARLES H. CLARK, *Managing Editor,*

Publication Office: Prince and Lemon Sts., Lancaster, Pa.

Editorial and General Offices: 65 Franklin St., Boston, Mass.

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Vol. VII **October, 1937** **No. 12**

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Entered as second-class matter, November 17, 1932, at the Post Office at Lancaster, Pa., under the Act of Congress of March 3, 1879.

Issued monthly at Prince and Lemon Streets, Lancaster, Pa., for United States Institute for Textile Research, Inc., Boston, Mass.
Made in United States of America.

Subscription price $5.00 a year. Single copies .50.

The Editor's Page

NOW that an important and extensive program of scientific and economic textile research is in progress it seems logical to make reports of its progress a feature of the annual meetings of U. S. Institute for Textile Research. This the committee on arrangements for our eighth annual meeting, to be held in New York City, Thursday, Nov. 4, is planning. Two important reports are already arranged for; one by Dr. Wanda K. Farr, director at Boyce Thompson Institute for Plant Research of the Chemical Foundation's research on the chemistry of cellulose, who will report on important new "Cellulose" Analyses; another will be a report by Dean Joseph H. Willits and associates, of the Wharton School of Commerce and Finance, on Progress of the Survey of Production and Distribution Organization in the Textile Industries. This study is now approaching completion, and, while final results cannot be expected at that date, the report to be rendered at the annual dinner should be found of vital interest to both manufacturers and merchants.

In addition to the regular meeting of the corporation for the submission of annual reports and the election of directors, there will be a research conference in the afternoon, and a dinner in the evening. The preliminary program and other details will be mailed to members in the near future, and meantime they are urged to make plans to be present Nov. 4. The conveniently located Hotel Commodore is the place of meeting.

* * *

Research Results Needing Interpretation

APPEARING in this issue is the final report of the research on the Microbiology of Textile Fibres, which has been conducted for several years at Massachusetts Institute of Technology, under the direction of Prof. S. C. Prescott, by Dr. Bryce Prindle, a Senior Fellow of The Textile Foundation. The objects of the study were (1) to make a comprehensive survey of the microbiological and biochemical relationships between various micro-organisms and the textile fibres with which they are associated, and (2) to correlate this information, if possible, with the strength and usefulness of the fibres.

Object (1) has been very conclusively attained for representative samples of cotton and wool, although Dr. Prindle ends his final report with a suggestion for additional fundamental work on the growth of mildew organisms in raw cotton. The results of the second objective, while adding materially to fundamental knowledge, probably will require interpretation to render them intelligible and useful to many practical manufacturers. This, if not already arranged for, should be.

* * *

Scientists Slow to Accept New Concept

WE are indebted to Dr. H. DeWitt Smith, and to the International Association for Testing Materials, for the privilege of publishing in this issue, and prior to its appearance in the latter's "Congress Book," the

paper and discussion on "The Structure of Cellulose" that Dr. Smith prepared by invitation for the congress of the association, held in London last April. Dr. Smith describes in outline the fundamental facts as to cellulose structure that are generally accepted, and clearly indicates the structural features that remain controversial. The outstanding feature of Dr. Smith's discussion in his non-controversial presentation of Dr. Wanda K. Farr's contributions on the structure of cellulose, a vital feature of which is that cellulosic fibres "possess a dual structure consisting of discrete microscopically visible particles of cellulose embedded in a framework or space lattice of non-cellulosic cementing material which appears to be largely pectic in nature." Dr. Smith held that this concept "accounts adequately for many facts of behavior which we have previously tried to explain in other ways, and it also sheds new light on some of the disputed findings and theories." In effect, he held that scientists engaged in cellulose research should be willing to reconsider disputed findings in the light of this concept, instead of merely expending time and effort in combating it.

* * *

May Indicate New Uses for "Cordura"

THE possible market for sails of Du Pont "Cordura" rayon yarn is by no means as large as that for heavy-duty tires; nevertheless, the properties of the yarn and fabric that influenced their use for the big quadrilateral jib of successful America's Cup defender Ranger should indicate their adaptability for additional new uses. They are described in an article in the September issue of *The Du Pont Magazine*, entitled "Rayon Rode With Ranger," as follows:

"It was found that sails made of a fabric of Du Pont 'Cordura' rayon yarn were stronger, didn't pull out of shape as easily and would tear only half as readily as the regular type of sailcloth. Their smooth surface reduced 'skin friction'—allowed the wind to slide off the surface quicker, giving greater driving force. And fabric woven of 'Cordura' rayon yarn proved inherently mildewproof, an ideal quality in sails because they are continually subject to dampness and wet going. Furthermore, tests revealed that 'Cordura' rayon sails allowed very little air to leak through. (In the case of Ranger's big jib du Pont chemists went even a step further; they developed a special coating which increased this natural virtue of the new fabric.)"

* * *

To Expand Research and Service Work

A NEW LABORATORY, completely equipped for the scientific solution of sizing, printing and finishing problems, has been established in Providence, R. I., by Stein, Hall & Co., Inc., specialists in starches, dextrines and gums, New York City. The work will be in charge of F. G. LaPiana, assisted by David Truax. Frank W. Perry will be the resident chemist. Close liaison will be maintained with the main laboratories in New York. A new and enlarged research program is being started at the latter. M. Cushing has been engaged as research chemist, and will devote his time exclusively to pure research in starch and dextrine chemistry, under the direction of G. V. Caesar, laboratory director.

Stein, Hall & Co., Inc., was one of the original sponsors of the warp sizing research of U. S. Institute for Textile Research, started in 1935, and has been a financial contributor and active co-operator since then.

"Such modern miracles as the new synthetic resins, high-test steel alloys, and the development of uses for the photo-electric cell have been made possible only because the chemical, steel and electrical industries were willing to devote millions of dollars and years of research to the study of fundamental problems. We believe that similar research in starch and dextrine chemistry will eventually contribute important results," says Edwin Stein, vice-president.

* * *

Vacuum Extraction Prior to Drying

CENTRIFUGING and vacuum slot extraction of moisture from textiles prior to drying was one of the subjects presented and discussed at conferences which preceded the organization of U. S. Institute's research on textile drying that is now in progress at the National Bureau of Standards. That this phase of the removal of moisture from textiles is important, and that it involves problems requiring scientific research are demonstrated by the following questions submitted to U. S. Institute, and answered by Chairman Hopkins of the Administration Committee for the Drying Research:

Questions

"The United States Institute for Textile Research is doing a lot of work on the subject of textile drying. If some work could also be done on the operations preliminary to textile drying, maybe just as beneficial results could be obtained, if not more.

"What we particularly have in mind is vacuum slot extraction of our heavyweight woolen cloth piece goods. After they have been vacuum extracted and before they are ready to go through the drier, the 100% Virgin Wool fabrics contain 70–80% moisture; the shoddy-rayon fabrics contain 100% moisture.

"If this moisture content could be cut 50%, then not only could the speed of our drier be increased probably 25%, but also our drying costs would be cut probably 25%.

"Below is a summary tabulation of numerous vacuum slot extraction tests:

Speed of Vacuum Extractor in Yds. Per Min.	% Moist. Content Pc. Goods after Vac. Extraction		
	100% Virgin Wool Cloth	Shoddy & Wool Cloth	Shoddy & Cotton Cloth
48	83%	100%	——
36	78%	88%	101%
27	70%		
11	66%		

"We ran these tests on a variable slot vacuum extractor. We used such a width that gave the lowest moisture content. We also used such a degree of vacuum that gave the lowest moisture content. But in spite of

(*Continued to P. 451.*)

Microbiology of Textile Fibres

VII. Growth of Mildew Organisms in Raw Cotton at 25° C. and Relative Humidities of 70 to 95 percent

By BRYCE PRINDLE*

Senior Fellow of Textile Foundation

Summary

1. As measured by means of bacterial counts on nutrient agar plates, there was no increase in the number of molds in a single series of samples incubated at relat at relative humidities of 70 to 95% at 25° C.

2. As measured by means of plate counts on Czapek's solution agar, there was a marked increase in the number of molds in a single series of samples incubated at relative humidities of 82 to 95%.

3. Of the many varied types present in the original myco-flora of the samples, only the Penicillia *and* Aspergilli *grew over the range of humidities from 82 to 95% as evidenced by counts on Czapek's solution agar. A single exception was noted in the case of the sample incubated at 95% R.H., a large number of Actinomycetes being observed on nutrient agar plates made for counting bacterial flora.*

Introduction

It is commonly known that raw cotton will mildew readily under damp conditions. The degree of moisture necessary has been a matter for considerable investigation in the past, and, more recently, investigators have made exact measurements of the amount of moisture necessary for the germination of the spores of many mildew organisms.

In so far as the author could discover, however, there has been no critical observation of the changes which take place in the natural microflora of normal raw cotton stored at various high humidities. As such changes are the cause of mildew, it was considered to be of fundamental importance to study them under controlled conditions. The work reported in the following pages is a report of an experiment which was carried out with two objectives in mind:

* Dr. Prindle, as a Senior Fellow of the Textile Foundation, worked under the direction of Prof. Samuel C. Prescott, Massachusetts Institute of Technology, Cambridge, Mass.

This is Contribution No. 103 of the Department of Biology and Public Health, Massachusetts Institute of Technology, Cambridge, Mass.

1. To measure the limiting relative humidity for the growth of micro-organisms on raw cotton at 25° C.
2. To observe the numbers and types of micro-organisms which developed in samples of raw cotton at 25° C. over a range of relative humidities of 70% to 95%.

Experimental

a. Apparatus.—As the purpose of this experiment was to demonstrate the effect of different relative humidities on the development of the natural micro-flora of raw cotton, it was necessary to have an apparatus by means of which test samples could be incubated at constant humidity, constant temperature, and freedom from contamination with micro-organisms not originally in the fibre mass. Preliminary experiments indicated that this could conveniently be accomplished by use of the apparatus illustrated in Fig. 1.

FIG. 1. Constant Humidity Apparatus.

An eight-inch desiccator was used as a conditioning chamber. It was fitted with a perforated procelain plate and a glass sample rack. The top was sealed on by means of a broad band of sheet rubber. To eliminate

the majority of micro-organisms from the apparatus, the jar and plate were scrubbed with 1/1000 mercuric chloride solution, rinsed with sterile water, and dried with a sterile towel. Contamination of the fibre samples was prevented by flaming the glass racks immediately before use.

b. Choice of Cotton Fibre for Mildewing.—In undertaking an experimental study of the development of micro-organisms in a mass of cotton fibre, it was considered of primary importance to know: (1) the origin and history of the sample, (2) the purity of the fibre sample in terms of content of sound cotton fibre, (3) the original micro-flora of the sample.

The primary interest in the first of these points was to establish approximately the age of the fibre and to know that it was a representative sample of American origin. Through the kindness of the Berkshire Fine Spinning Associates it was possible to obtain samples of fibre from the 1936 cotton crop. This was typical American cotton of medium staple and had not been subjected to any fumigation or sterilization treatments which might alter its microbic content or chemical composition.

The second point is of interest because of the fact that the cotton fibre and substances associated with it were to be the only source of food material for microbic growth during the course of the mildewing experiments. In previous experiments raw cotton containing considerable debris was used and rapid growth of molds was observed at humidities of from 85% to 95%. In that case, it was concluded that a good part of the observed increase in the number of molds may have been due to their growths on bits of leaves and stems, and it was observed that such bits of material as were present were in fact covered with mold growth. This, of course, did not represent true mildew of the cotton and it was believed that the results of the experiment might be misleading when interpreted in terms of cotton deterioration. In the present case, therefore, it was deemed advisable to use a sample which was in a state of purity at least as good as that found in grey goods and perhaps better. A consideration of material available, led to the choice of a combed cotton sliver for this work. This material was observed to be very uniform and clean.

The third point is perhaps the most important in that it involves consideration of the active agents which were to determine the whole nature of the end result of the experiment. In previous work it has been demonstrated that certain types of molds and bacteria are typical of freshly harvested raw cotton and that certain of these organisms gradually lose their viability giving way to less abundant but more resistant types. Previous experiments had demonstrated also that the less resistant types of molds were the more destructive to cotton fibre when grown on it in pure culture. In a previous attempt to follow the growth of mildew organisms in raw cotton, however, it was noted that under conditions of from 70% to 95% relative humidity at 25° C., the only increase in numbers that could be noted took place among the types of molds which persist in samples which have been stored for long periods of time, namely, the *Aspergilli* and *Penicillia*. To confirm these results, it was decided to experiment with a sample of cotton sliver which contained a micro-flora representative of newly grown raw cotton. The sample used was about six months old at the time of the experiment. As will be noted below, its micro-flora was found to be normal for freshly harvested raw cotton except that the proportion of resistant mold types found was a little higher than usual. This may have been either a reflection of the storage period under-

gone or of the elimination of waste material from the fibre. In either case, it was decided that there was present a good representation of all types of organisms common to cotton and that the results of a mildew experiment with this material would be typical.

c. Methods.—In carrying out this experiment it was necessary to provide methods for maintaining samples of cotton sliver at constant relative humidity and temperature and for the counting and isolation of molds and bacteria from samples at the beginning and at the end of the experimental period.

The method for maintaining samples under constant physical conditions was the following. Test samples of one gram of cotton sliver were hung on the sterile glass racks of the apparatus described above; the desiccators were filled at the bottom with a suitable glycerol solution and closed with wide rubber bands. The whole was placed in an air thermostat at 25° C. In this experiment, no provision was made for aerating the samples after the initial closing of the jars.

For the purpose of facilitating handling, all samples were measured out to approximately one gram before incubation. It was found that the sliver was of sufficient uniformity so that measured lengths of the same would be sufficiently alike in weight to be considered interchangeable for the purposes of this experiment. Lengths were measured from the sliver by scorching at the correct points with a pair of parallel, hot, platinum wires. Lengths of 10 in. each were used as test samples and were found to weigh 1.00 ± 0.05 grams.

The methods used for counting and isolating the types of molds and bacteria from samples during the experiment were the same as those which have been described previously (1934, Prindle).

d. Experimental Procedure.—The original micro-flora of the combed sliver was first investigated. Ten inch samples were used. Duplicate samples were shaken up with sterile water, and the suspension of material resulting was poured off, diluted, and plates made for bacterial and mold counts. Bacterial counts were made with nutrient agar as a medium and mold counts were made with acidified Czapek's solution agar as a medium. All counts were made in duplicate.

Samples for mildew development were then prepared with aseptic precautions and hung on well flamed glass racks. These were put away in closed chambers at 25° C. and incubated for a period of 30 days at relative humidities ranging from 70 to 95%. At the end of that time, a sample was removed from each jar, examined for evidences of mildew, and the numbers and types of molds and bacteria associated with it were determined.

e. Experimental results.—Frequent observations of the samples of cotton slivers being incubated revealed no discolorations or other changes in appearance suggestive of mold or bacterial growth. At the end of this period, it was decided to remove samples for counting and typing of their micro-flora, inasmuch as it was felt that sufficient time had elapsed for a significant increase in numbers to have taken place even in the case of very slow growing organisms.

Upon opening of the jars a strong mildew odor was noted in those maintained at 86 to 95% relative humidity, but not in those incubated at lower humidities. Crude manual tests of the fibre in each jar gave no indication of bad tendering in any case, but samples were not submitted to exact measurement by machines especially designed for strength tests.

There was no indication of discoloration other than a slight change from the original mild creamy lustre of the combed sliver.

The changes which took place in the microbic populations of the test samples over the whole range of humidities employed are tabulated below.

TABLE I

Growth of Molds and Bacteria on Combed Cotton Sliver During 30 Days Incubation at 25° C. and Relative Humidities Indicated

Original Counts

Sample No.	Molds/gram	Bacteria/gram
1	1,500	700,000
2	1,200	650,000

Counts After Incubation

% R.H.	Molds/gram	Bacteria/gram
71	1,000	190,000
76	1,000	170,000
82	16,500	120,000
86	1,350,000	———
90	830,000	———
95	5,600,000	———

TABLE II

Types of Micro-organisms Isolated from Cotton Sliver Before and After Incubation at Certain Relative Humidities at 25° C.

Original Micro-flora

Bacteria—Mixed colony types, pigmented and colorless.

Molds—Mixed types giving to Czpek's solution agar plates the "frozen pudding" appearance characteristic of raw cotton. Types present were: *Alternaria, Hormodendron, Aspergillus, Penicillium, Mucor,* and several other brightly pigmented Fungi Imperfecti.

Micro-flora after 30 Days Incubation

Bacteria—Little change in appearance of colonies obtained on nutrient agar.

Molds—

% R.H.	Types of Molds	% of Total Population
71	None	
76	None	
82	Loose green *Penicillium*	95
86	Bright blue *Aspergillus*	25
	Grey-green *Aspergillus*	40
	Blue-green *Penicillium*	30
90	Blue-green *Penicillium*	80
	Buff *Aspergillus*	20
95	Blue-green *Penicillium*	35
	Buff *Aspergillus*	60
	* Actinomycetes	

* Large numbers of these organisms were noted on the nutrient agar plates made from this sample.

Discussion

The first observation worthy of note is that the bacteria not only did not increase, but died out in large numbers on three of the samples held t humidities of 70 to 82%. It is probable that this also happened in the case of three samples incubated at higher humidities, for the nutrient agar plates made from these samples were covered with mold colonies which rarely develop on that medium in the presence of large numbers of bacteria.

Of more significance from the standpoint of mildew is the marked increase in numbers of molds. This was noticeable in the sample incubated at 82% R.H. but was very much greater in the range of 86 to 95%. In terms of moisture content of the cotton, an R.H. of 82% corresponds to about 10.5%, and 86% to about 12%. These figures agree well with the figures of 8 to 9% which have been frequently quoted as the limits for mildew development. The present result is also in good agreement with the recently published figures of Galloway (1935), who states that the minimum relative humidity for the germination of the majority of a large number of pure mold cultures which he investigated lies between 80 and 85%.

It is also of interest that a moldy odor was noted in the case of the three samples incubated at 86, 90, and 95% R.H., but not in the rest. The occurrence of this odor in this particular case is exactly correlated with a large increase in mold count. As noted above, no evidence of deterioration was observed in these samples. This suggests that the detection of a mildew odor in cotton may be a very sensitive test for exposure to damp, and consequently to mildew hazard. A further investigation of this phenomenon would doubtless yield information of value in estimating the quality of raw cottons.

The greatest point of interest in the discussion of this experimental work lies in the analysis of the micro-flora of the various samples. As previously stated, the original micro-flora of these samples consisted of many different micro-organisms common to raw cotton. As the bacteria did not grow under the experimental conditions our chief interest is in the molds.

Unlike the pure culture germination tests of Galloway, the molds which were to be isolated from these samples for counting and identification had to germinate, grow, and reproduce themselves in competition with many others. Cotton fibre was their only substratum. Those which predominated at the end should therefore be considered potential agents of mildew in raw cotton, and the experiment was really a controlled production of the initial steps in mildew.

Of all the varied types that were isolated from the original cotton, only the *Aspergilli* and *Penicillia* grew sufficiently to be counted in high dilution on Czapek's solution agar plates. The only exception to this was noted in the case of the sample incubated at 95% R.H. In this case, a large number of actinomocytes were observed on the nutrient agar plates. These were not found at all in the original mold counts.

The development of different mold types at the different humidities is also in agreement with the results of Galloway. In this case, only one organism, a *Penicillium,* increased in the sample incubated at 82% R.H. At the higher humidities, this organism was not found at all. In the case of the sample incubated at 86% R.H., three principal types of molds were

isolated. Two of them were *Aspergilli* and were identified as *Aspergillus Sydowi* (Bainier & Sartory) and *Aspergillus fumigatus* (Fresonius). The third was an unidentified, velvety, blue-green *Penicillium*. At the humidities of 90 and 95%, only the same unidentified *Penicillium* and *Aspergillus terreus* (Thom) were found on the Czapek's solution agar plates. As this is but a single experiment, and there is no guaranteee that all of the organisms found in these samples were present in all of the original samples, no generalized conclusions can be drawn. It would be very interesting to continue research along the same line until enough data could be obtained to determine whether the molds which grow on raw cotton actually have lower and upper limits as suggested by the results presented here.

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(*Continued from P. 442.*)

all these measures, you will note that in cutting the speed from 36 yds./min. 11 yds./min., only 12% more moisture was taken out.

"Why is this? What is the actual reason why it is so difficult to take out any more moisture after you reach a certain moisture content? What other conditions are needed to take out more moisture? If the physics of vacuum slot extraction were thoroughly understood, probably it would be an easy matter to get more thorough extraction.

"Increasing the vacuum doesn't always give better extraction. We found that by laying a strip of felt the entire way across the vacuum slot and over the cloth that is to be extracted, that a very high degree of vacuum is obtained, but that the extraction is very much poorer due to the fact that very much less air is being sucked through the cloth. Evidently it is not the degree of vacuum that counts, but the amount of air sucked through the cloth. Incidentally we found that extracting a second time didn't do enough good to warrant such an additional procedure. Why is this?

"We think that all the above is calling to the Institute's attention something that has real practical significance."

Answers

"Your data regarding the effect of volume of air in the removal of moisture is interesting. Apparently there are at least three distinct phases in the removal of water from saturated cloth by means of vacuum extraction:

"In the first phase, the surplus water loosely held on the surface of the fabric and trapped in the interstices of the fabric construction is mechanically removed by being swept out of the fabric by the draft of air over and through it. In this phase, temperature probably has little

effect, but volume of air and velocity of air constitute the controlling variables.

"In the second phase, the surplus water mechanically attached to the surface of the fabric and its component parts has been removed and the water is being evaporated from the surface of the fibres. The attraction of this layer of water directly contacting the fibre surface is much stronger than that of the superficial layers of water which have been previously removed. In this phase the actual volume and velocity of air have little effect in mechanically sweeping off the moisture. As long as the movement of air is sufficient in volume to assure reasonably dry air and the rapid removal of air which may be saturated, the actual volume of air passing through the fabric at this point is unimportant. The velocity of the air passing through the fabric will have some effect on the speed of drying through its effect in minimizing the thickness of the layer of moist air which directly surrounds the fibre surfaces. As this last film of moist air decreases in thickness, the speed of evaporation is of course increased. In this phase, therefore, as long as a moderate volume of air is moved, an increase in the volume of air would have little effect, and an increase in velocity of the air would have within reasonable limits a slight effect on the speed of drying. Here the temperature of the air and the degree of vacuum maintained would become more important as the rate of evaporation would increase with temperature and with vacuum.

"The third phase of the drying occurs when the evaporation from the surface of the fibre becomes slower than the diffusion of the moisture from the interior of the fibre to the outside. In this phase temperature of the fabric becomes critical and the degree of vacuum and temperature of air become less important.

"We agree with you that the operations are important by which superficial moisture is removed from materials before they are subjected to the so-called drying operations in which the last moisture is removed. It will no doubt be necessary that our program eventually include a study of these operations. In the original conferences on drying, it was indicated, however, the greatest need for data was centered about the phenomenon which takes place as the textile fibres approach dryness. The first steps of our program are therefore built on this premise.

"We appreciate your comment and will keep your suggestion in mind as we build up the future program of the drying research."

"*CAPITAL in our various industries must come to realize more thoroughly than at present that continuing support of research is the only possible insurance against the rapid obsolescence which results in the destruction of capital.*" ROBERT E. WILSON.

The Structure of Cellulose

By HAROLD DEWITT SMITH, Ch.E., Ph.D., F.T.I.

AUTHOR'S NOTE: This paper was prepared by invitation for the Second International Congress of the International Association for Testing Materials which was held in London, April 19–24, 1937.

The first part comprises the prepared report which was sent to all members before the meeting of the Congress. The praiseworthy instructions to authors required the compression of the assigned subject into a concise, factual report. The papers were not read at the Congress sessions. Instead, each author was given five minutes to comment on the significance of the reported facts.

The second part consists, therefore, of my comments when this paper was called up for discussion at the session of Group C on Organic Materials on April 21. It draws attention to the far-reaching and fundamental significance of the facts reviewed in the formal report.

The paper and comments together with discussion from the floor will appear in the forthcoming "Congress Book." My indebtedness to the International Association for Testing Materials is hereby gratefully acknowledged for permission to print the paper and comments in full prior to publication in the "Congress Book."

CELLULOSE is a natural substance which forms an important part of the fibrous structure of all species of plant life. It has not been isolated as an absolutely pure chemical individual.

Qualitative analyses of purified cellulose from every natural source which has been investigated reveal the presence of carbon, hydrogen, and oxygen. Quantitative analyses of various samples show slight but real variations which have been ascribed to residual impurities. The results all fall very close to the proportion: six carbon atoms to ten hydrogen atoms to five oxygen atoms.[1]

Chemical investigations, confirmed by X-ray diffraction studies, have revealed that these twenty-one atoms are arranged as in β-glucose anhydride[2] (Fig. 1). These glucose anhydride rings are joined through the 1 and 4 positions by oxygen bridges to form a primary valence chain of unascertained length. Alternate rings in a chain are rotated through 180° about the chain axis[3] (Fig. 2). The length undoubtedly varies from chain to chain between probable limits (in native cellulose) of 100 and 3,000 glucose residues.

This is the so-called molecular chain of cellulose. It is the nearest approach to the usual concept of "molecule," but cannot rightfully be so called because these chains are undoubtedly not of definite equal size as are true molecules. Individual chains have not been isolated from cellulose, but their presence in very dilute solutions of cellulose esters has been strongly indicated.[4, 5]

One step more has been definitely determined; namely, in native and in purified cellulose, these chains are grouped in space with their axes parallel and the rings related to one another,[5, 6] in some such way as is illustrated schematically in Fig. 3. The unit cell deduced from X-ray diagrams is not a physical or chemical entity, but a geometric unit which, when projected in three directions in space, reproduces the orientation revealed by these diagrams.

Hence, the configuration of the chains is crystalline within very small volumes, but the X-ray diagrams by which it was determined also indicate that the crystalline order is interrupted at undetermined intervals which show some degree of periodicity. The forces which align the primary valence chains into these crystalline aggregates are thought to be the secondary valences or polar forces of the hydroxyl groups which lie along the sides of the chains.

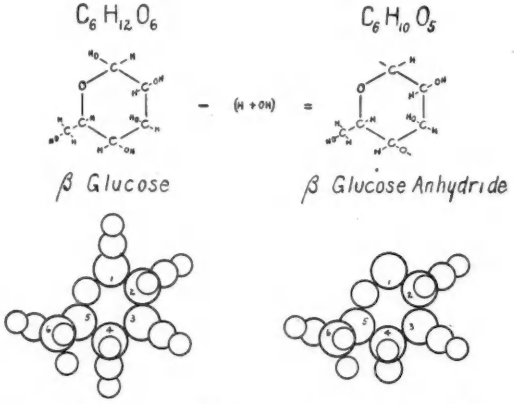

FIG. 1. β-glucose and β-glucose Anhydride: Empirical Formulae, Structural Formulae, and Space Models.

This structure is almost universally accepted as correct because it is confirmed by chemical analysis of cellulose, glucose, and intermediate products and derivatives; by chemical synthesis of one of the simpler saccharides of the homologous series; and by X-ray studies of these various substances. It conforms accurately to the chemical behavior of cellulose as a tribasic alcohol. It has been thought to explain the effects of oxidation and acid hydrolysis on the properties of cellulose, but these interpretations may well be subject to modification. Several recent painstaking surveys of the extensive cellulose literature include consideration of data supporting this structure.[7, 8, 9]

Beyond this point lies a region in which confusion reigns. The unsuccessful search for a definite "molecular weight" has evolved into a study of average size and size distribution of the colloidal fragments of cellulose and its derivatives in dispersing media. The values so obtained vary widely with the method used and the preparatory treatment of the sample.[10] Furthermore, recent disclosure of the true nature of cuprammonium-cellulose solutions invalidates much of this work.[11]

In efforts to explain the physical behavior of cellulose with respect to swelling in water and in alkalies, the viscosity of its solutions, and its elastic and plastic properties under various conditions of physical and chemical treatment, several submicroscopic structures in succession have been postulated and questioned. Micellae,[3] continuous chain structure,[12] and periodic structure variation[13] are some of the concepts which have been

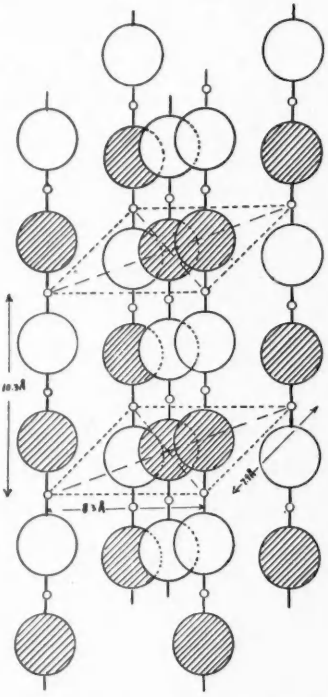

FIG. 2. Portion of Cellulose Molecular Chain: Structural Formula and Space Model. (From Astbury, W. T., "Fundamentals of Fibre Structure," p. 110, by permission.)

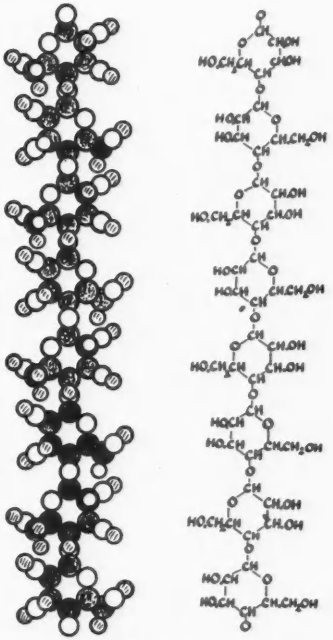

FIG. 3. Schematic Representation of Arrangement of Molecular Chains in Native Cellulose and of Crystallographic Unit Cell.

introduced in noteworthy attempts to explain how the molecular chains are grouped to form the next structural unit about which there is no dispute; namely, the microscopically visible fibrillae of which the fibre walls are composed.

This gap in our certain knowledge lies between the molecular chain, whose diameter is of the order of several ten-thousandths of a micron, and the fibril, whose diameter is of the order of one-half to one micron. The

cross-section of a fibril is, therefore, large enough to consist of several million molecular chains side by side.

Fibrillae have been observed in every type of native cellulosic fibre which has been examined. The fibres are composed of these fibrillae in a tightly packed, orderly arrangement. In every type of native cellulosic fibre, the fibrillae are approximately parallel to one another, but they are oriented in relation to the fibre axis in a manner which is characteristic of each particular type of fibre[14] (Fig. 4a).

A number of unrelated microscopic studies, published during the last one hundred years, have recorded the breakdown of fibrillae into shorter units which have been given such names as dermatasomes,[15] granules,[16] crystals,[17] and fusiform bodies;[18] and the presence of membranes within the fibre wall has been noted.[19] The existence of an undetermined cementing material has also been postulated from time to time.[20]

The mode of formation, the structure, and the composition of the fibrillae have been recently explained by a series of direct microscopical observations supported by a confirmatory optical, X-ray, and chemical tests. This work resolves the confusion arising from previous microscopic studies and thereby clearly reveals a new concept of the structure of cellulosic fibres.[21, 22, 23] While these findings have not bridged the whole gap, they have cut through many of the tangled theories and facts and provide a new viewpoint from which to examine the entire subject of cellulose structure and behavior.

In living cellulosic fibres from many sources, the formation of fibrillae by the joining together, end to end, of ellipsoidal particles which appear to form in the cell sap has been observed. By the careful swelling of mature fibres such as flax, ramie, wood, cotton, and hibiscus (the last two not only of recent growth, but also in specimens ranging in age from one hundred years to several thousand years), the fibres have been seen to break down into the well-known fibrillae and these, in turn, into particles of similar size, appearance, and properties to those observed in the building-up of growing cellulosic fibres (Fig. 4b, c, d).

Each particle is covered with a thin layer of non-cellulosic material which serves as a cementing material to join them together. Tests indicate that this contains pectic matter, probably in conjunction with other constituents. The exact composition of the cementing layer is not yet known. It may well vary somewhat from one type of fibre to another and even within a single fibre. Upon removal of this thin envelope by a suitable solvent, the remaining particle is proved by staining methods, by refractive indices, and by X-ray diffraction pattern to be cellulose as we have heretofore learned to identify it. The approximate dimensions of these particles are given as: length 1.5 μ, diameter 1.1 μ. Such a particle could contain about three million cellulose molecular chains side by side with a maximum possible chain-length of about three thousand glucose residues.

The great gap in our knowledge lies within the particle. This dual structure seems to eliminate the necessity for submicroscopic divisions such as have been postulated in order to explain various experimental data, but apart from the fact that the chains within the particle must be well oriented, we do not know whether their arrangement is simple or complex.

The structure of native and of purified cellulosic fibres is, therefore, distinctly two-phase, comprising a definite framework, or space lattice, of

non-cellulosic cementing material within which are microscopically visible particles of cellulose.

Swelling studies indicate that the thickness of the non-cellulosic cementing material between layers of fibrillae in the fibre wall is greater than that between the individual fibrillae or between the particles in a fibril, also that the inner layers swell more readily than the outer layers. But the fact that these visible cellulose particles can be isolated from native or purified fibres by such mild treatments as immersion in very dilute solutions of alkalies, acids, or ammonium oxalate at 75° C. proves that the continuous primary valence chains of cellulose cannot extend throughout

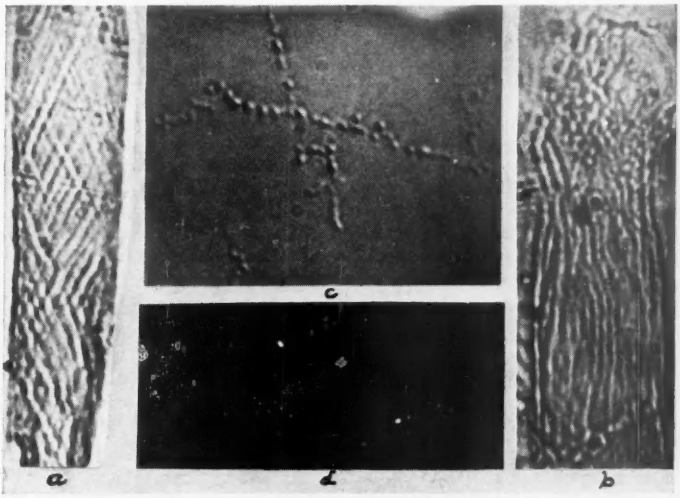

FIG. 4. *a*. Spiral Fibrillae in Wall of Cotton Fibre from 14-day Boll (X2400).

b. Fibrillae and Particles in Cotton Fibre treated with a Solvent for the Cementing Material (X2400).

c. Separated Cellulose Particles from Mature Cotton Fibre (X1700).

d. Separated Cellulose Particles in Polarized Light (X1400).

(Photomicrographs by courtesy of W. K. Farr.)

the fibre beyond a length equal to the length of this cellulose particle. Nor can the overlapping ends of these chains or groups of chains form an uninterrupted structure throughout the length of the fibre.

The cementing material constitutes a strongly hydrophilic substance whose properties and behavior are distinct from those of the cellulose particle. The amount of the cementing material is small in proportion to the amount of cellulose present, but both its nature and its distribution through the fibre structure are of tremendous importance with respect to all of the properties of cellulosic fibres, and, therefore, to the future of cellulose research.

Author's Comments

The formal discussion of this paper on April 21 at the session of Group C on Organic Materials was opened by the following comments by the author:

Mr. President, Ladies, and Gentlemen:

Inasmuch as my paper, in accordance with the instructions of the Association, is confined to a brief statement of the present knowledge of "The Structure of Cellulose" which allowed little room for comment on the significance of the more recent findings, I appreciate this opportunity to supplement it with a few remarks.

Our present knowledge of cellulose is an outstanding example not only of that international cooperation in science which was praised by the speakers at the Banquet, but also of the very effective cooperation of the various departments of science, including Chemistry, Physics, Botany, and Microscopy.

As I have pointed out, the atomic arrangement of carbon, hydrogen, and oxygen in cellulose as β-glucosidic rings joined together by primary chemical valences to form long molecular chains, has been well established and is widely accepted because it is supported by both physical and chemical experimental evidence including analysis and synthesis, quantitative reactions such as esterfication and etherification, as well as by the physical evidence of optical birefringence and X-ray diffraction patterns.

Some ten years ago when the controversy as to whether the cellulose "molecule" was a small discrete unit or a long chain structure was at its height, a botanist, Sponsler, stepped forward with the first adequate picture of the molecular chain structure and so provided the impetus which resulted in the more correct and perfect elucidation of the true "molecular" structure that has since been worked out by Meyer and Mark, by Astbury, and others.

I think it very interesting that we are now being reminded once more by a botanist, Farr, that in any study of a product of plant life the botanical viewpoint must *never* be forgotten. Farr's work has clarified the conflicting observations of the past hundred years. As she herself has pointed out, many observers from Valentin, in 1837, to the present day have seen particles in the cytoplasm of growing plant cells. Many have seen fibrils disintegrate into fragments, and fragments into particles. Dr. Farr's contribution has been to clarify and illuminate the method of cell wall formation and the structure of the cell wall, and to demonstrate beyond a doubt that cellulosic fibres, whether in the raw state or carefully purified, possess a dual structure consisting of discrete microscopically visible particles of cellulose embedded in a framework or space lattice of non-cellulosic cementing material which appears to be largely pectic in nature. This structure accounts adequately for many facts of behavior which we have previously tried to explain in other ways and it also sheds new light on some of the disputed findings and theories.

Pectic substances are complicated derivatives of galacturonic acid whose structures are still only partially understood. They are strongly hydrophilic with amazing powers of swelling to viscous dispersions or solutions. Analyses have indicated the empirical formula of pectin to be $C_{20}\ H_{28}\ O_{33}$ and the percentage composition as calculated from this formula is very close to that calculated from the cellulose formula $C_6\ H_{10}\ O_5$. Hence, the small

variations in the ultimate analyses which have been made on purified celluloses may well be due to small but varying amounts of cementing material present as the "impurity" which has been suspected of affecting the results.

Furthermore, the highest yield of glucose by the quantitative hydrolysis of purified cellulose which I have found in the literature is approximately 95%. Hence, a part of the 5% which is unaccounted for may well be due to the cementing material.

The solution of cellulose in Schweitzer's reagent (cuprammonium solvent) has been definitely demonstrated to be a solution of the cementing material only, leaving the unaffected cellulose particles colloidally dispersed. The viscosity of such solution is due primarily to the cementing material and not to the cellulose. Instead of being broken down into molecular chains or small groups of chains by this solvent as has been thought, the cellulose remains unaffected as particles dispersed in the viscous solution of the cementing material.

All of the authenticated X-ray data is in accord with this dual structure; in fact, the most recent work on the influence of small quantities of non-cellulosic material in masking the cellulose diffraction pattern of young fibres strongly supports it.

The cementing material answers very well to the description of the "Kittsubstanz" or the "amorphous cellulose" or "periodic regions of non-crystallinity" which various investigators have noted and sought to explain.

The swelling of cellulose in water, which has been called "intermicellar," is adequately explained by the swelling of the cementing material which leaves the cellulose particles essentially unaffected. Swelling in alkalies of mercerizing strength evidently affects not only the cementing material, but also penetrates into the cellulose particles thus causing the well-known alteration of the X-ray diagram to that known as the "mercerized" diagram.

With respect to the chemical reactions of cellulose, their interpretation in the light of this structure is not yet so clear. There is no reason for doubting the essential correctness of such reactions as esterification, etherification, oxidation, and acid hydrolysis, as these affect the cellulose particle itself and the atomic constitution of the cellulose chains as described in the first part of my paper. However, a careful review of the entire chemical behavior of purified cellulose may well reveal that the presence of this cementing material in the hitherto unsuspected roll of fibre framework or skeleton may modify the interpretation of much excellent data which has already been accumulated and may influence the course of much work still to be done.

For example, the acid hydrolysis of cellulose, which is now considered to be a progressive breaking down of the oxygen bonds between glucose residues and hence a shortening of the chains, may well be in fact a progressive breaking down or removal of the cementing material only. This would produce the observed progressive decrease in tensile strength and in cuprammonium viscosity, the increased solubility in dilute alkalies, and, very possibly, the rise in copper number (reducing power) either by the formation of reducing groups in the cementing material itself or at the ends of the cellulose chains by the breakdown of possible linkages between the cellulose particles and the cementing material at those points. In this connection it is interesting to note in the literature that, whereas the copper number of purified cellulose is 0.05 and that of glucose is 300, hydrolyzed

cellulose, in which the copper number has risen to only 5, has been found to fall to a powder under the slightest mechanical stress.

This example is cited simply as one instance of the probable influence of this new concept of cellulosic fibre structure on the course of cellulose research. The affect of this dual structure on the current theories of the mechanism of strength and other physical properties of cellulosic fibres is equally challenging.

Many such examples of the need for revision of conclusions arise when reviewing the very excellent and painstaking studies of cellulose which have been and are being conducted in the laboratories of Europe, of the United States, and of Japan.

Thus, the study of the structure of cellulose stands today at a crucial and an exciting point. If given due and critical consideration by every student of cellulose, this concept bids fair not only to shed new light in the unknown region which lies within the cellulose particle by eliminating the confusion which undoubtedly reigns in interpreting good data because of the hitherto unsuspected presence of a chemically and physically distinct material in the purified cellulosic fibres themselves, but also to illuminate those whole fields of science and of industry which are concerned with the structure of cellulose.

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Abstracts

Committee on Abstracts and Bibliography:
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Address, C. H. Clark, Sec., 65 Franklin St., Boston, Mass.

I. Fibres (Synthetic and Natural) and Fibre Analysis

Animal Fibres: X-ray Structure. H. Biermann. *Monatsh. Seide u. Kunstseide*, 1937, V. 42, P. 48–50, 93–4; abs. in *J. T. I.*, June 1937, P. A331.

A general discussion of the study of fibre structure by means of X-rays and the results of recent studies of silk, wool, hair, and other protein fibres. (C)

Cellulose: Crystal Structure. K. H. Meyer. *Ber. Dtsch. Chem. Ges.*, 1937, V. 70, P. 266–74; abs. in *J. T. I.*, June 1937, P. A345.

Recent work on the crystal structure of cellulose is reviewed and reasons are advanced for believing that the two chains occupying the unit cell are arranged in opposite directions instead of the same. For example, cellulose hydrate as represented by rayon has the same lattice as that represented by mercerized ramie. If rayon is regarded as the "statistical average" of chains pointing in both directions why suppose the chains in the natural fibre to be all arranged in one direction? A new space model of cellulose is given and discussed. It is compatible with X-ray data. The authors regard as a most important feature of X-ray analysis the proof that the chains are built up of cellobiose units, but point out that it does not provide a means of exploring small deviations such as the supposed presence of carboxyl groups or the configuration of end groups. The new conception of chains pointing in opposite directions is reconcilable with the conception of closed ring systems. (C)

COTTON HAIR PRIMARY SUBSTANCE: X-RAY DIAGRAM AND CONSTITUTION. J. Gundermann, W. Wergin and K. Hess. *Ber. Dtsch. Chem. Ges.*, 1937, V. 70, P. 517–26; abs. in *J. T. I.*, June 1937, P. A341. (C)

FLAX: REDUCTION OF THE PECTIN CONTENT OF—DURING RETTING WITH HOT WATER. H. Felser. *Mell. Textilber.*, 1937, No. 6, P. 409.

According to the view now generally accepted, the cementing substance of the flax cells, known as pectin, is exposed to bacterial decomposition during retting, which leads to loosening of the cell structure. Samples of flax being retted were taken from time to time during the process, dried, and the pectin content determined, using the Tollens-Lefèvre process to determine the galacturonic acid, the characteristic constituent of pectin. The high pectin content of flax fibre that is technically completely retted, or has even been retted beyond that point, is due to the high pectin content of the cortical cells or the residues thereof that have not been completely removed. Determinations of the pectin contained in extracts of retted flax show that the pectin left behind becomes only slighly more soluble as bacterial action proceeds. (C)

BAST FIBRES: PROBLEMS IN INDUSTRIES PRODUCING. Max Ludtke. *Angew. Chem.*, 1937, V. 50, P. 291–6; abs. in *C. A.*, 1937, V. 31, Col. 4821.

The following subjects are discussed: (1) warm water retting with anaerobic bacteria, (2) dew retting with aerobic bacteria, (3) aerobic retting, (4) chem. decompn., (5) mech. fibre prepn. and (6) long fibres, tow and chaff. Nine references. (W)

LANITAL: PROPERTIES OF. E. Da Schic. *Boll. assoc. ital. chim. tessile color*, 1936, V. 12, P. 180–4; abs. in *C. A.*, 1937, V. 31, Col. 4125.

Lanital consists of soft yellow-white fibres, burning more readily than wool with burnt-horn odor and no swelling. The fibres are cylindrical with slightly pigmented smooth sides. Like wool, it is colored yellow with Zn chloroiodide. On treatment in 10% NaOH at ordinary temp., washing in H_2O, immersion for 5–10 min. in methylene blue soln., and washing in H_2O, it becomes deep blue; wool remains colorless, or light greenish blue. Deeply dyed Lanital must be bleached before this test. To destroy Lanital in mixts. with cotton, linen and hemp, the fabric is boiled with 10% NaOH soln. for ½ hr. In 58° Be. H_2SO_4 Lanital loses in 2 hr. 1–5% in wt. In ca thiocyanate the loss reaches 4–5%. Lanital contains 15.2% H_2O, and 3.85% ash before alk. treatment. (W)

NATURAL VEGETABLE TEXTILE FIBRES: EXISTENCE OF TRANSVERSE ELEMENTS IN. R. Haller. *Helv. Chim. Acta*, 1937, V. 20, P. 199–203; abs. in *C.A.*, 1937, V. 31, Col. 4820.

Transverse elements should cause smooth, even broken surfaces. Neither cotton nor bast fibres show such surfaces. Fibres treated by S's method show great swelling but no evidence of transverse elements. The barrel-shaped swelling of natural, and also of artificial fibres, is due to a cuticle, differing from the rest of the fibre. The natural and artificial fibres show similar phenomena and the latter are not considered to have transverse elements; hence the results observed are due to a membrane. The transverse elements described by S are merely remains of cuticle. (W)

SILK FIBRE: STUDIES IN THE STRUCTURE OF. H. Kaneko. *Bull. Sericult. Silk Ind.* (Japan), 1937, V. 9, P. 105–13 (in English, P. 113–4); abs. in *C. A.*, 1937, V. 31, Col. 4821.

Sericin (silk glue) can be detected on the fibre by Zimmermann's reagent, *o*-phthalaldehyde. The silk fibre (fibroin) is not colored by this reagent, but when dissolved and pptd. by $(NH_4)_2SO_4$ the ppt. gives the color reaction with the reagent. Damaged fibres also show the reaction. Cf. *C. A.*, *31* 2827. (W)

SCOURING OF WOOL WITHOUT ALKALI. P. Savournin. *Tiba*, 1937, V. 15, P. 157–61; abs. in *C. A.*, 1937, V. 31, Col. 4502.

A brief discussion and description of the production of polysulfonated vegetable oils, showing their merits for the scouring of wool, particularly the finer grades (cf. Fr. pats. 796,463, *C. A.*, *30*, 6011, and 801,920, *C. A.*, *31*, 1635). (W)

X-RAY SPECTROGRAPHY ON MORPHOLOGY OF CELLULOSE. I. DETERMINATION OF THE MACROMOLECULAR LATTICE OF NATIVE CELLULOSE BY NEW X-RAY METHODS OF STRUCTURE ANALYSIS. II. CELLULOSE: CRYSTALLINE AND FIBRILLAR STRUCTURE. E. Sauter. *Z. physikal. Chem.*, 1937, V. B35, P. 83–128; abs. in *J. T. I.*, June 1937, P. A348; *Eastman Kodak Abs. Bull.*, June 1937.

It has been observed that, in monochromatic fibre diagrams of the most varied preparations of native cellulose suitably illuminated, there is always present a more or less intense line lattice spectrum. This shows that a particularly high degree of lattice distortion is characteristic of these fibres. The existence of ultra-crystalline fibrillar lattice "splinters" confirms the chain structure for cellulose as opposed to the micellar structure of Meyer and Mark. These lattice deformations are chiefly significant in explaining the physical properties of cellulose fibres (*e.g.*, their flexibility), their heterogeneous reactions, degradation and swelling phenomena. (C)

II. YARNS AND FABRICS

COTTON FABRICS: EFFECTS OF LAUNDRY METHODS ON. A. E. Ginter, M. Shadduck, M. Partlow and T. Pearson, University of Missouri, Columbia, Mo. *J. Home Econ.*, May 1937, P. 319–26.

This study of the effects of commercial and home laundry methods on cotton muslins does not lead to clear-cut comparisons between them. Commercial washing seems to be slightly easier than home methods on new materials but not on materials which have been frequently washed. Ironing by commercial methods is harder on the material than by home methods. In commercial laundering, the ironing weakens the material more than does the washing; in home laundering, it is the washing that does more harm, except in the first few times of launderings. (C)

COTTON FABRICS: TESTS ON UNUSED AND ON "WORN-OUT" PLAIN-WEAVE. S. Davison and A. E. Ginter, Univ. of Missouri, Columbia, Mo. *J. Home Econ.*, May 1937, P. 333–35.

The lengthwise (warp) threads of the 33 materials tested in this study were stronger than the widthwise (filling) ones, and as a result the width-

wise ones gave out before the others. In general, the study suggests that consumers could select fabrics more intelligently if they had definite information on such points as thread count and tensile strength. (C)

DESIZING COTTON MATERIALS: LABORATORY METHODS FOR. R. E. Howell. *Am. Dye. Rptr.*, June 14, 1937, P. 342–45.

Discusses the malt-enzyme, the acid-alkali and the ammonium-persulfate methods. (C)

EMBOSSING AND BOIL-OFF ON FINISHED CREPE FABRICS: EFFECT OF. Jas. J. McGibbon. *Am. Dye. Rptr.*, June 14, 1937, P. 335–38.

Complete copy of paper presented at Rayon Technical Conference, May 14–15, and the discussion of same. (C)

FELTS: MANUFACTURE OF. Robert A. C. Scott. *Rayon Tex. Mo.*, 1937, May, P. 55–6, 59; June, P. 57. (C)

MOLD: IMPROVED METHOD FOR THE EXAMINATION OF COTTON GOODS SPOTTED WITH. E. Meissner. *Deut. Wollen-Gewerbe*, 1937, V. 69, P. 272–4; abs. in *C. A.*, 1937, V. 31, Col. 3291. (W)

(RAYON) STAPLE ON COTTON SYSTEM. H. O. Kennette. *Tex. Wld.*, May 1937, P. 78–9.

Paper read at meeting of A. S. M. E. at Greenville, S. C., April 7, 1937. (C)

SILK AND RAYON: WEIGHTING. S. Urban. *Kunstseide*, 1937, V. 19, P. 60–4; abs. in *J. T. I.*, May 1937, P. A260.

The weighting of silk and rayon is discussed and the difference between processes that involve simply precipitation of weighting materials on the fibre and processes in which the weighting materials are deposited in the fibre and the fibre is caused to swell is pointed out. Various investigations of the effects of weighting on the strength and other properties of silk and of the decrease in strength and wearing qualities of weighted silks on storing are reviewed. (C)

SPINNING PROCEDURE FOR COTTON SAMPLES. H. A. Hancock. *J. T. I.*, May 1937, P. T161–T175.

The technique employed in the Spinning-Test Mill at Giza (Egypt) is described. The standard error of a spinning-test under conditions specified is shown to be about 1%. In comparing the spinning values of old or new varieties, the strength level to which the yarns are spun is found to be of little consequence. Providing the cottons are given identical treatment, they rank in much the same order whether spun from combed or from carded preparation, in fine or in coarse counts, in warp twist or in doubling weft, over the range of Egyptian cottons. A spinning in a medium counts carded yarn gives sufficiently accurate information for most purposes. (C)

TEXTILE-DRYING INSTALLATIONS. P. Beckers. *Z. ges. Textil-Ind.*, 1936, V. 39, P. 624–28; abs. in *C. A.*, 1937, V. 31, Col. 2441.

A detailed review of the theory and devices used with many references to the literature. (W)

WHY CRÊPES GO WRONG. Henry Miedendorp, Jr. *Tex. Wld.*, May 1937, P. 107–8.

Discusses causes and prevention of shires, fingermarks, diamonds, and other weaving defects. (C)

WOOL AND MOHAIR. Werner Von Bergen. *Am. Dye. Rptr.*, May 17, 1937, P. 271–79.

The article discusses the physical and chemical properties of the two main animal fibres and their differences and the behavior of the fibres in the manufacturing processes of woolen and mohair goods. (C)

WOOL-QUALITY NUMBERS. James H. Kennedy, Jr. *Tex. Wld.*, May 1937, P. 76–7.

Originally a wool of 56s quality could be spun to 56s worsted count. Down through the years, however, wool-quality numbers have been applied to lower and lower qualities, with the result that today what is recognized as a 56s quality will spin only to 38s yarn and in fact will be unlikely to be used for anything finer than 36s. For these reasons the author's table showing the present relation between quality numbers and spinning counts will be found valuable. (C)

WOOL: STUDY OF SOME OF THE FACTORS THAT ALTER THE COLOR AND STAPLE LENGTH OF FROSTED AND REGULAR. J. H. Kennedy, Jr. *L. T. I. Bulletin*, Series 40, No. 4, May 1937.

Presents the results of a thesis prepared under the direction of Prof. H. J. Ball of Lowell Textile Institute, the specific objectives being to measure the color of frosted and regular wool top; to study the factors that influence the color difference; to analyze the factors that change the average staple length of top. Conclusions were mainly as follows: Frosted wool top had better color than regular wool top processed in the same manner. The color of top, both frosted and regular, varies with the degree of cleanness of the scouring liquor. Four bowls of scouring for frosted wool produce top of better color than do three or less. The staple lengths of frosted wool and regular wool tops scoured in medium dirty scouring bowls are alike. The staple length of naphtha treated frosted wool is slightly longer than that of naphtha treated regular wool. Under certain conditions the frosted process tends to decrease somewhat the fibre length of top. The wool scouring process appears to have more effect on the length of staple in the top than the frosting process. (C)

III. CHEMICAL AND OTHER PROCESSING (NOT OTHERWISE CLASSIFIED)

ADSORPTION ANALYSIS OF VAT DYES. I. Bilik. *Novosti Tekhniki*, 1936, No. 42–3, P. 42; abs. in *C. A.*, 1937, V. 31, Col. 2823.

The freshly prepd. vat dye is added to the adsorbent consisting of Al_2O_3 covered with a layer (several mm.) of hyposulfite mixt. After a partial adsorption of the dye, 1.5% hyposulfite soln. is added and the differently colored zones on the adsorbent are observed. Preparation of the adsorbent is described. (W)

AZO DYES ON RAW COTTON: USE OF. H. Schmidt. *Deut. Färber-Z.*, 1937, V. 73, P. 3–4; abs. in *C. A.*, 1937, V. 31, Col. 2823.

A detailed description including specific dyeing directions. (W)

CELLULOSE MATERIAL: NEW METHOD FOR DETERMINATION OF SUBSTANTIVE DYES IN THE FIBRE AND THE ADSORPTIVE CAPACITY OF. H. Schmidt. *Deut. Färber-Ztg.*, 1936, V. 72, P. 15–16, 23–4, 32; abs. in *C. A.*, 1937, V. 31, Col. 2438.

The method allows the rapid detn. of 0.00005–0.00001 g. of dye in the fibre with an accuracy of 2%. (W)

CHEMICAL STUDIES OF SILK FIBROIN. II. GENERALITY OF FIBROIN COMPONENTS. III. DYEING PROPERTIES OF FIBROIN COMPONENTS. H. Kaneko and C. Komatsu. *J. Agr. Chem. Soc. Japan*, 1936, V. 12, P. 800–6, 1125–31; abs. in *C. A.*, 1936, V. 31, Col. 3448; 1937, V. 31, Col. 2827. (W)

CHEMISTRY OF DYES: REVIEW OF. C. Courtot. *Rev. gén. sci.*, 1936, V. 47, P. 608–19; 1937, V. 48, P. 31–5; abs. in *C. A.*, 1937, V. 31, Col. 2437. (W)

COLLOIDAL ASPECTS OF DYESTUFFS. A. M. Patel. *Indian Textile J.*, 1937, V. 47, P. 137–8; abs. in *C. A.*, 1937, V. 31, Col. 2437. (W)

CHLORINATION OF WOOL. E. Meissner. *Deut. Wollen-Gewerbe*, 1936, V. 68, P. 1411–12; abs. in *C. A.*, 1937, V. 31, Col. 2440.

Chlorinated wool has the luster and feel of silk and absorbs dyes better than untreated wool. If chlorinated wool is boiled 1 min. in dil. NH_4OH soln. no turbidity is formed. If the final residue of the NH_4OH soln. is evapd. with a little NaOH and if after cooling a few drops of $CuSO_4$ is added the soln. turns violet. Untreated wool produces no turbidity and no purple color. Directions are given for the proper chlorination and for titration of the bleaching-powder solns. The use of chloramines for bleaching is discussed. Such org. products have a milder action than bleaching powder and hypochlorites and greatly facilitate the operation of the treatment. (W)

COTTON: CONSTITUTION AND AFFINITY FOR—OF DISAZO DYES FROM SUBSTITUTED DIAMINODIPHENYLS. H. H. Hodgson and P. F. Holt. *J. Soc. Dyers Col.*, May 1937, P. 175–77. (C)

COTTON DYES. E. Meissner. *Deut. Wollen-Gewerbe*, 1936, V. 68, P. 1427–8; abs. in *C. A.*, 1937, V. 31, Col. 2439.

A survey of the newest developments. (W)

DRY METHODS OF DYEING. Erika. *Deut. Färber.-Ztg.*, 1936, V. 72, P. 67; abs. in *C. A.*, 1937, V. 31, Col. 2440.

The use of nonaqueous solvents in dyeing is reviewed. (W)

DYED MATERIALS: FADING TESTS. S. Pestalozzi. *Zellstoff u. Papier*, 1937, V. 17, P. 53–7; abs. in *J. T. I.*, May 1937, P. A278.

A useful general review of fastness problems, including the influence of the substrate, the light source, the effects of humidity and temperature, and methods for assessing fading. (C)

DYEING OF STAPLE RAYON. L. Bonnet. *Teintex*, 1937, V. 2, P. 77–8; abs. in *C. A.*, 1937, V. 31, Col. 3284. (W)

DYEING OF ACETATE RAYON AND ACETATE SPUN RAYON. E. Quensell. *Klepzig's Textil-Z.*, 1937, V. 40, P. 155–6; abs. in *C. A.*, 1937, V. 31, Col. 3284. (W)

DYEING PROPERTIES OF COTTON FIBRE: INFLUENCE OF NATURAL ADMIXTURES IN CELLULOSE ON THE. I. P. P. Viktorov and E. O. Vil'dt. *J. Applied Chem.* (U. S. S. R.), 1936, V. 9, P. 1649–60 (in German P. 1660); abs. in *C. A.*, 1937, V. 31, Col. 2825. (W)

DYEING TROUBLES WITH CRÊPE FABRICS. G. L. Atkinson. *Silk J.*, 1937, V. 13, No. 152, P. 32–3; abs. in *C. A.*, 1937, V. 31, Col. 2439.

Single-shade dyes are better than mixts. Dyeing at temp. over 160° is disadvantageous. Temp. control is important. A minimum of dyeing assistant such as Glauber's salt is best, not exceeding ½ the customary amt. in a dyeing formula. The result should be not over 10% rejections. (W)

DYES ON TEXTILE FIBRES: IDENTIFICATION OF. Ellis Clayton. *J. Soc. Dyers Col.*, May 1937, P. 178–97.

Presents in tabular form analytical methods for the identification of dyes on wool, silk and related fibres, and also on cotton and other cellulosic materials than cellulose acetate, which latter are to be included later; for each type of dye the analytical results to be expected are also tabulated. In few instances are dyes referred to by their commercial names, the *Colour Index* of the Society of Dyers and Colourists being referred to for the latter. The author and Prof. F. M. Rowe, who assisted him in this work, are editors of the *Journal of the Society of Dyers and Colourists*. The tables are prepared along the lines employed by Prof. A. G. Green when his tables were published in 1905, but cover the many new types of dyes developed since then. The extent to which simplicity of analysis has been attained is indicated by the fact that only one main reducing agent is recommended, this reagent being "Formosul G." The details of analysis given in the 14 tables are amplified in an introductory discussion. (C)

FADING OF DYED WOOLENS, PARTICULARLY GERMAN SHODDY. H. Gerstner. *Monatschr. Textil-Ind.*, 1937, V. 52, Fachheft I, P. 9–11; abs. in *C. A.*, 1937, V. 31, Col. 3699. (W)

FADING OF SOME RAYONS AND SPUN RAYONS. W. Haussner. *Spinner u. Weber*, 1937, V. 55, No. 9, P. 30–1; abs. in *C. A.*, 1937, V. 31, Col. 3701. (W)

FLUORESCENCE, FLUORESCENT INTERMEDIATES AND SYNTHETIC ORGANIC COLORS. Translation by P. J. Wood of a paper delivered before the French Society of Electricians June 25, 1935, by M. Pierre Mougeot. *Am. Dye. Rptr.*, May 31, 1937, P. 291–98; *Tex. Rsch.*, Dec. 1937, P. 115, 116.

This short review of the applications of fluorescence of intermediates and synthetic organic coloring matters shows that these photo-luminescences are likely to interest industry in the most diversified fields. Close collaboration between dyestuff laboratories and electrical illuminating engineers should result in still further enlarging the field of practical utilization of fluorescence. (C)

Improvement of Felting Power (of Textiles) by Chemical Treatments. G. Rordorf. *Spinner u. Weber,* 1937, V. 55, No. 9, P. 34–5; abs. in *C. A.,* 1937, V. 31, Col. 3703. (W)

Indigosol Jigger Dyeing. S. Kosche. *Klepzig's Textil-Z.,* 1937, V. 40, P. 91–2; abs. in *C. A.,* 1937, V. 31, Col. 2825.

Advantages of indigisol dyes over indanthrene dyes are described and specific dyeing directions are given. (W)

Mechanical and Chemical Advances in Dyeing Methods. Arthur H. Pittinger. *Can. Chem. Met.,* 1937, V. 21, P. 7–8; abs. in *C. A.,* 1937, V. 31, Col. 2439.

A brief review of methods of acid dyeing at temps. as low as 60°, of applying synthetic resins to cotton fabrics to render them crease-resistant, and of application of synthetic resins and condensations in dyeing such as to endow cotton with an affinity for acid dyes, normally applied exclusively to wool. Several patented processes are outlined. (W)

Mechanism of Diazotization. H. Schmid. *Ber.,* 1937, V. 70, P. 421–24; abs. in *J. Soc. Dyers Col.,* May 1937, P. 209. (C)

Mercerizing: Effect of. Eber Midgley. *Tex. Wld.,* June 1937, P. 96–7.

The author deals with effect of mercerizing on diameter, strength and other properties of cotton yarn. (C)

Mixed-fibre Textiles and the Finishing of these Textiles. Hans Engel. *Klepzig's Textil-Z.,* 1937, V. 40, P. 167–9; abs. in *C. A.,* 1937, V. 31, Col. 3289. (W)

Naphthols—Cold or Hot? H. I. Creslow. *Dyer,* 1936, V. 76, P. 619–21, 631; abs. in *C. A.,* 1937, V. 31, Col. 2823.

Difficulties of penetration, economical use of old dyebaths, and differences in substantivity of different naphthols are claimed to be solved by using hot naphthol baths. Also with hot baths, the amts. of naphthol and diazo compd. required for a given shade can be estimated. (W)

Oxidation Dyeing: Theory of. II. Oxidation of *p*-phenylenediamine at Various pH. V. Pchelin. *J. Applied Chem.* (U. S. S. R.), 1936, V. 9, P. 846–54 (in English P. 854); cf. *Byull. Tsentral. Nauch.-Issledovatel. Lab. Soyuzkhempроma,* 1936, V. 8, P. 58–66; abs. in *C. A.,* 1937, V. 31, Col. 3283. (W)

IV. Research Methods and Apparatus

Analysis of Wool for Fibre Diameter and Length: Comparative Examination of Methods of. Part I. Diameter Measurements in Wool Tops. G. R. Stanbury and H. E. Daniels. *J. T. I.,* June 1937, P. T188–T201.

Previous methods of fineness measurement in wool tops are discussed and reasons given for the adoption of the present microscopic projection method. Details of experimental procedure are given in order to reduce errors of measurement to a minimum. Various sampling methods are in-

vestigated and the importance of distinguishing between "true" and "biased" samples is stressed, in view of the correlation between length and diameter in wool tops. The method finally recommended is that of the cross-sectional sample, full details of which are given. The final section is a statistical treatment of results obtained by this method, with special reference to (a) the significance of the difference between the sample means of two given tops and (b) the significance of the difference of the sample mean of a top from a given grade boundary.

Part II. A. B. Wildman and H. E. Daniels. *Ibid.*, P. T202–T205.

In this section of the paper a technique is decribed by which the measurement of fibre-fineness by the optical method can be carried out on raw wool. The method of sampling is based upon systematic zoning. In this operation the original sample is first divided into primary sub-samples or zones which are judged by eye to be about the same size; from each of these a very small "sheaf" of fibres is withdrawn to make up a composite sample. It is indicated that the procedure described in the first part of the article can be applied to a sample of raw wool with the confident expectation that reliable and representative results will be obtained. (C)

Apparatus for Testing the Fastness-to-Light of Materials: New. J. F. H. Custers. *Philips Tech. Rev.*, Sept. 1936, P. 277–81; abs. in *Eastman Kodak Abs. Bull.*, June 1937.

A testing device is described consisting essentially of an ellipsoidal reflector which focuses the light from a tungsten filament lamp upon the material whose stability to light is to be tested. It is claimed for the device that it enables the light-stability of materials to be determined by a short time-exposure. (S)

Chemical Research Laboratory: What the—is Doing. *Dyer*, Jan. 15, 1937, P. 71; abs. in *Rayon Tex. Mo.*, July 1937, P. 92.

A description of an inspection tour of the Chemical Research Laboratory of the Department of Scientific and Industrial Research made by representatives of *The Dyer* who were conducted by the Director, Sir Gilbert Morgan. Mentions research being pursued, including investigations on synthetic resins, tar and rubber, water pollution, corrosion, microbiology, etc. Laboratory demonstration of simple and cheap way of preparing synthetic resins. Now investigating these resins for use as water softener agents. Of interest to textile industry is the study of fabric decay. State that materials made from cellulose acetate yarn were entirely proof against microbiological attack. Experiments proved that cotton and flax plus partial acetylation tended to resist attacks of micro-organisms. On question of silk degumming by micro-organisms, found that out of 160 species of lower fungi tested that *Aspergillus niger* was most effective; if enzyme solution was kept on the acid side, degumming was carried out in one to two hours. (C)

"Dirks" Dry-Tester-Regulator. Ismay Dirks Appliances Ltd. *Tex. Wkly.*, 1937, V. 19, P. 151–2; abs. in *J. T. I.*, May 1937, P. A264.

The "Dirks" appliances for measuring, recording and regulating the moisture content of sized warp, cloth, paper, etc., are based on the electrostatic principle, and are claimed to control moisture content within 0.3% on the "too damp" side and 0.2% "too dry." (C)

EXAMINATION OF TEXTILE AND OTHER MATERIALS: PORTABLE ULTRA-VIOLET FLUORESCENCE LAMP FOR. D. A. Derrett-Smith. *J. T. I.*, May 1937, P. T145–T160.

The paper describes a small portable ultra-violet fluorescence outfit which has been designed that enables the material under examination to be "scanned" with ultra-violet light, the lamp being brought to the material instead of the material to the lamp as is the case with the fixed types of fluorescence apparatus. (C)

ELECTRICAL INSULATING MATERIALS: THERMAL CONDUCTIVITY. J. A. Weh. *Gen. Elec. Rev.*, 1937, V. 40, P. 138–40; abs. in *J. T. I.*, June 1937, P. A335.

A direct electrical method of measuring the thermal conductivity of a single specimen of test material is described. The apparatus consists of hot and cold plates to set up a temperature drop across the sample and instruments and accessories for measuring the heat flow. Some typical results are tabulated, expressed as thermal resistivity and thermal conductivity. In general the error in these measurements is less than $\pm$ 10% which is usually within design requirements. The factors contributing to the total error are discussed individually. The conductivity of a varnished cloth is given as 0.0019 to 0.0023 watts/sq. cm./°C./cm. and that of cellulose acetate as 0.00185. (C)

HYDROCELLULOSE AND OXYCELLULOSE: DETECTION OF. R. Haller. *Klepzig's Textil-Z.*, 1937, V. 40, P. 79; abs. in *C. A.*, 1937, V. 31, Col. 4824.

No sp. tests are known for hydrocellulose; its presence is deduced from neg. tests for the presence of oxycellulose and from the lowering of the strength of vegetable textiles. Tests for the detection of oxycellulose are: (1) *Sn-Au Reaction.* Place the sample for 1 hr. in a 1% soln. of crystd. $SnCl_2$ contg. 1–2 drops of glacial AcOH, rinse with distd. water and add a very dil. soln. of $AuCl_3$. The damaged parts will turn reddish brown if they had undergone an alk. treatment. (2) *Prussion blue reaction.* Place the damaged material for 1 hr. in a 10% soln. of $FeSO_4$, rinse and add a 1% soln. of $K_4Fe(CN)_6$; the weakened spots will become blue if oxycellulose is present. (3) *Nessler's reagent.* In the presence of oxycellulose the textile will assume a yellow to orange tint, which soon changes to gray. (4) *Cochineal reaction.* Place the material for 1 hr. in a 1% $(AcO)_2Pb$ soln. with occasional stirring, rinse 4 times with distd. water and treat for 5 min. with a warm suspension of cochineal. The damaged parts will turn bright crimson, while the undamaged material will not be dyed at all. (W)

INSTRUMENTATION STUDIES. XV. A COMPARISON OF THE CARTER AND THE GURLEY STIFFNESS TESTERS. By the Staff of the Institute of Paper Chemistry. *Paper Trade J.*, June 3, 1937, P. 43–5.

As in the Smith-Taber and Gurley instruments, the Carter tester involves the application of a force to bend the paper through a constant angle, which in the latter instrument is established as 90°. The range of the Carter is less than that of the Gurley, because of breakdown of the elasticity of paper at high values of stiffness and large angles of bending. (C)

MEASUREMENT OF THE ELONGATION OF SINGLE FIBRES: NEW METHOD FOR THE. W. Weltzien and H. Biermann. *Monatsh. Seide Kunstseide*, 1937, V. 42, P. 133–6; abs. in *C. A.*, 1936, V. 30, Col. 5798; 1937, V. 31, Col. 3702.

The Krais, Polanyi and Schopper methods are reviewed; they are characterized by the simultaneous increase of the load and elongation during the test. The greatest difficulty in all of these methods is due to the fact that the time factor has not been taken into consideration completely. A new method is described in which the fibre is weighted with a const. load and the elongation is detd. in its dependence upon time. The app. is shown together with the measuring microscope and devices for suspending the fibres, regulating air currents and adjusting air humidity. (W)

MICRO-ELECTROPHORESIS CELL WITH NON-POLARIZABLE ELECTRODES: VERTICAL. H. A. Abramson, L. S. Moyer and A. Voet. *J. Am. Soc.*, Dec. 1936, P. 2362–4; abs. in *Eastman Kodak Abs. Bull.*, June 1937.

The construction and use of a vertical-type cataphoresis cell are described. It has been checked by comparing measurements on protein-coated collodion particles, asbestos needles, and blood cells with measurements obtained in a calibrated horizontal cell and a U-tube. Agreement within the usual limits of experimental error was obtained. The advantages and disadvantages of the vertical cell are discussed. (S)

PHOTOCHEMISTRY: APPLICATION TO TEXTILE PROBLEMS. H. Freytag. *Textil-ber.*, 1937, V. 18, P. 89–91; abs. in *J. T. I.*, June 1937, P. A349.

The task and aims of textile photochemistry are discussed and reference is made to some of the results already achieved. A program of photochemical work with textile interest is divided into sections for (1) fastness testing, (2) photo- and luminescence-analysis of dyes, etc., tendering influences, defects, etc., (3) development of photo-chemical processes of finishing and bleaching and synthesis of dyes and other products, and (4) photo-biology, applied to the stimulation of seeds and silk-worms, the killing of cocoons, retting, and the health of operatives. (C)

PROBLEMS, THEORIES AND RESEARCH METHODS IN TEXTILE AND DYE CHEMISTRY. R. Haller. *Bull. fédération intern. assoc. chim. textile couleur*, 1936, V. 2, P. 25–42; abs. in *C. A.*, 1937, V. 31, Col. 4123. (W)

RAYON: HOW TO DISTINGUISH BETWEEN VISCOSE AND CUPRAMMONIUM. A. Herzog and H. Ruckert. *Mell. Textilber.*, 1937, No. 7, P. 485.

The iodine azide reaction was used to distinguish between viscose and cuprammonium rayon. It was found that viscose rayon in every case gave a strong positive reaction, while the reaction with cuprammonium rayon only appeared sporadically and even then was only weak. Touching the cuprammonium fibres with the hand before applying the test has a considerable effect upon the result which can, however, be eliminated by extracting the sample first with petroleum ether and laying it with a pair of forceps in the iodine azide solution. The reaction is best carried out in a watch-glass under a magnifying glass or under a slightly magnifying microscope in a well ground out slide. (C)

V. Economics, Physics and Miscellany

Particles: Determination of Size by Means of a Microscope: Estimating the Error. F. Ehrenhaft. *C. R. Acad. Sci.*, 1937, V. 204, P. 40–1; abs. in *J. T. I.*, May 1937, P. A288.

An experimental method is described for estimating error due to diffraction when measuring, with a microscope, objects the size of which is small compared with the wave length used. The method consists in microphotographing in ultra-violet light of two perfectly spherical particles of the same substance, and of the same size; the spheres are then brought together by means of a special technique until they just touch. If the image is increased by diffraction then the images of the spheres will encroach upon each other in the neighborhood of the point of contact. If encroachment takes place the sum of the diameters measured horizontally will be less than that when measurements are made perpendicularly. This difference permits the determination in a simple manner of the error of the microscopic measure of the image of a single particle. (C)

Proteins: Properties of—as a Function of their Fine Structure. S. J. Przylecki. *Monatsh.*, 1936, V. 69, P. 243–69 (through *Brit. Chem. Abs., A*, II, 1937, P. 128); cf. Przylecki, Hofer and Frajberger-Grynberg, *Biochem. Z.*, 1935, V. 282, P. 362–73, also Przylecki, Cichocka and Rafalowska, *Ibid.*, 1936, V. 284, P. 169–76; abs. in *J. T. I.*, May 1937, P. A292. (C)

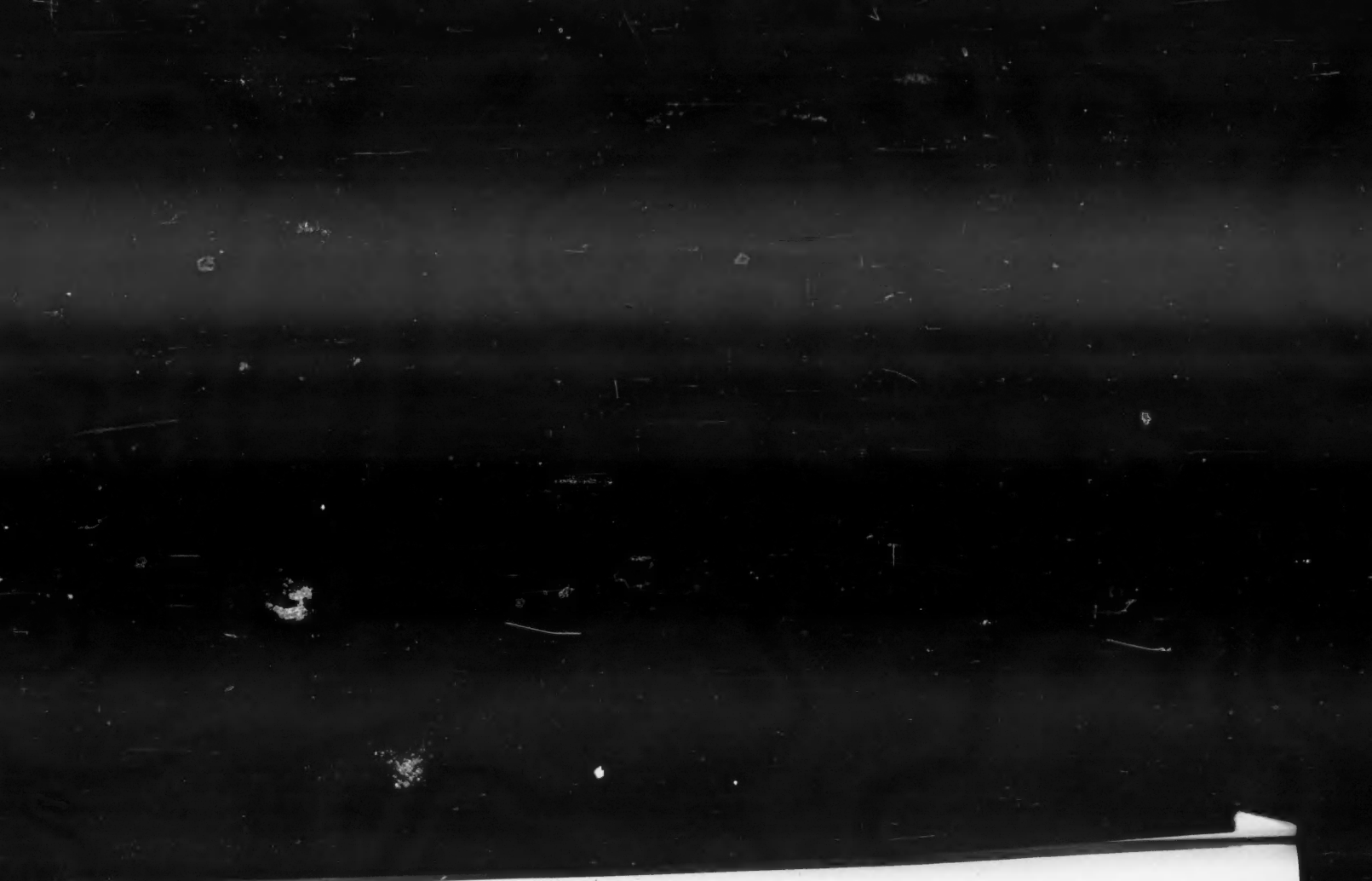
Rayon's Weaving Needs. Albert Palmer. *Tex. Wld.*, June 1937, P. 82–5.

This is an abstract of a paper presented by the author before the National Rayon Technical Conference in Washington, May 14, and showing how these needs have been met by the evolution of loom mechanisms superior to the old. (C)

Skin Temperature Thermometers. H. Pfeiderer and K. B. Büttner. *Abderhalden's Handb. biol. Arbeitsmethoden*, Abt. iv, Teil 13, P. 767–94; abs. in *J. T. I.*, May 1937, P. A288.

A general review of the measurement of skin temperature, with descriptions of useful thermo-couples. (C)

Starch Pastes and Lyophilic Sols: Viscosity. W. Gallay. *Canadian J. Rsch.*, 1936, V. 14, P. B391–403; abs. in *J. T. I.*, May 1937, P. A287. (C)

Starch: Constitution. H. Staudinger and E. Husemann. *Leibigs Ann. Chem.*, 1937, V. 527, P. 195–236; abs. in *J. T. I.*, May 1937, P. A289.

A formula for starch is suggested in which there are numerous side chains of glucose residues attached to a main chain. (C)